PROGRAM facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Hydrogen Turbines

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TURBINES FOR COAL-DERIVED FUELS

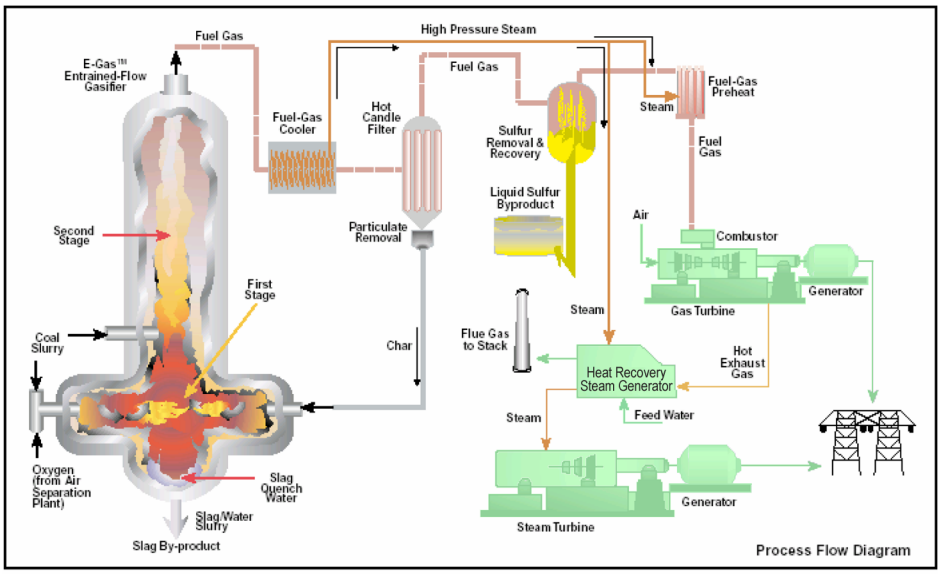
Background

For many years, the Department of Energy (DOE) and industry have worked to develop the concept of integrating coal gasification with clean, efficient gas and steam turbines to create Integrated Gasification Combined Cycle (IGCC) power plants. This development program has been sparked by the need for more efficient and lower cost power generation with the advantage of lowest possible emissions. Gasification is one of the most efficient and cleanest of available technologies for coal-based power generation, with emissions comparable to those of natural gas-based power production. The higher overall efficiency also results in a substantial reduction in emissions of greenhouse gases, especially carbon dioxide.

DOE's Fossil Energy Turbine Program manages a portfolio of R&D projects. These projects are designed to address the technical issues associated with the use of turbines in IGCC systems and applications, such as FutureGen, where hydrogen/electricity generation, and carbon management are the primary focus.

Turbines for Integrated Gasification Combined Cycle

Gasification is any process which produces synthesis gas (syngas), a gas consisting mainly of carbon monoxide and hydrogen. Gasification combines coal, oxygen and steam to produce syngas that is cleaned of impurities such as sulfur. This syngas can be used as a fuel for a gas turbine. When gasification processes are integrated with turbines to produce electric power, the system is called an integrated gasification combined cycle (IGCC) power system.



Typical Gasification Process Flow Diagram for IGCC Systems

CONTACT POINTS

Richard A. Dennis
Technology Manager
Turbines Program
National Energy Technology Laboratory
304-285-4515
richard.dennis@netl.doe.gov

Charles Alsup
Project Manager
National Energy TechnologyLaboratory
304-285-5432
charles.alsup@netl.doe.gov

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

Gasification systems like IGCC are environmentally friendly and, if properly designed, can minimize pollution while increasing hydrogen production. To be competitive in a deregulated power industry driven by increasingly stringent environmental regulations and to be the technology of choice, IGCC technologies must have thermal efficiencies greater than 50% (HHV), have capital cost less than $1,000/kW, emit very little sulfur or nitrogen oxides, and have the flexibility to capture and sequester carbon dioxide if desired. Of all advanced technologies currently under development, IGCC power systems are the ones that have potential to achieve all of these ambitious goals simultaneously. Essentially IGCC power systems offer the cleanest and potentially most cost effective way to utilize coal for power generation.

The DOE FE Turbine Program is focused on the improvement of turbine technology for IGCC systems by addressing specific cost and performance targets. Achieving these targets allows IGCC systems to attain the stated performance goals.

Turbines for FutureGen and Hydrogen Fuels

Hydrogen from coal is a highly desirable fuel and the Department of Energy (DOE) is continuing to implement a "hydrogen initiative" to make hydrogen-fueled power systems so inexpensive that they could become commonplace in America's power market during the next decade. Hydrogen fuel could not only help eliminate harmful emissions but reduce dependence on foreign supplies of oil, helping to stabilize a volatile market.

FutureGen is a $1 billion dollar initiative intended to create the world's first zero-emissions, coal-fired electric and hydrogen production plant. The 275-megawatt prototype plant will serve as a large scale engineering laboratory for testing new, clean-power, carbon-capture, and coal-to-hydrogen technologies. When operational, the prototype will be the cleanest fossil fuel-fired power plant in the world. The FutureGen plant, in all likelihood, will be based on coal gasification technology.

To help make FutureGen successful, the Turbine Program is addressing the technical issues associated with the utilization of high-hydrogen fuels. The technical issues for turbines in a FutureGen application, i.e., reduce emissions and cost and increase efficiency, are similar but more difficult in some ways than the issues for conventional IGCC applications.

An Artist's Rendition of FutureGen

Turbine Technology Cost and Performance Targets for IGCC Systems

- *Air Emissions*: Catalytic combustion or pre-mix technology for syngas / hydrogen fuels to reduce NO_X emissions to 3 ppm.
- *Plant Efficiency*: Increase firing temperature and improved integration to contribute 2–3 % points towards the 45-50 % (HHV) efficiency goal for coal-based IGCC.
- *Plant Capital Costs*: Increase specific power output by 15–20 % that results in a direct reduction in capital cost.
- *Availability*: Improved thermal barrier coatings (TBC) and early detection of TBC failure will allow higher firing temperatures and higher efficiencies with improved availablity.
- *Cost of Electricity (COE)*: Efficiency gains and improvements in availability reduce COE.
- *Carbon Management (FutureGen):* Turbines integrate well into systems designed for carbon management while producing electricity.